



Famine Early Warning Systems Network—Informing Climate Change Adaptation Series



A Climate Trend Analysis of Niger

Conclusions

- Summer rains have increased during the past 20 years and have almost returned to 1960–89 levels.
- Temperatures have increased by 0.6° Celsius since 1975, amplifying the effect of droughts.
- Crop yields are very low and stagnant, and the population is growing very rapidly.
- Niger has offset very rapid population growth with a large expansion of cultivated land.
- If the expansion of farmland slows down, stagnant yields and population growth could lead to increased food insecurity.

Food Security Context

Niger is a landlocked country (area: 1,267,000 square kilometers) with a population estimated at 16.5 million people; it has an annual growth rate of 3.6 percent and a total fertility rate of 7.6 births per woman, the highest fertility rate in the world (CIA, 2011). Niger's population is anticipated to double

by 2031. The agriculture and livestock sectors engage more than 80 percent of the population. Fourteen percent of its gross domestic product is generated by livestock production, supporting 29 percent of the population. Fifty-three percent of the population is actively involved in crop production. Fifteen percent of Niger's land is arable and located in a region mainly along its southern border with Nigeria. Millet, sorghum, and cowpea are Niger's principal rainfed subsistence crops. Rains, as in much of the Sahel, are marked by annual variability that increases northward. In dry years, Niger has difficulty feeding its population and must rely on grain purchases and food aid to meet its food requirements. In Niger, 1 year in 3 is associated with poor food security conditions.

This brief report, drawing from a multi-year effort by the U.S. Agency for International Development (USAID) Famine Early Warning Systems Network (FEWS NET), identifies a substantial recovery of rainfall in Niger, accompanied by increases in air temperatures. These analyses are based on quality-controlled station observations.

Rainfall Has Been Recovering Since the 1980s

Rainfall in Niger declined rapidly between 1950 and the mid-1980s and partially recovered during the 1990s and 2000s. Between 2000 and 2009, the average rainfall in Niger's crop growing districts was about 8 percent lower than the 1920–69 mean. The recent rainfall increases are probably due to the

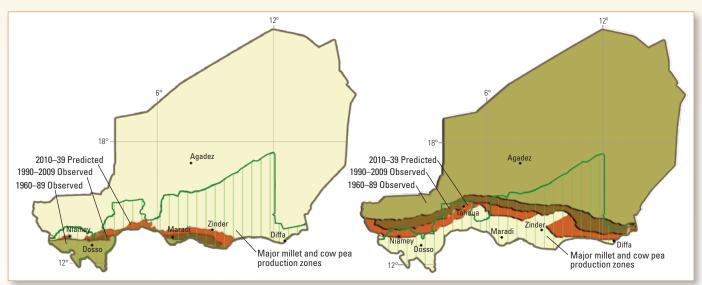


Figure 1. Climate change in Niger: The left map shows the average location of the June–September 500 millimeter rainfall isohyets for 1960–89 (light brown), 1990–2009 (dark brown), and 2010–39 (predicted, orange). The green polygons in the foreground show the main crop production districts. The right map shows analogous changes for the June–September, 30 degrees Celsius air temperature isotherms.

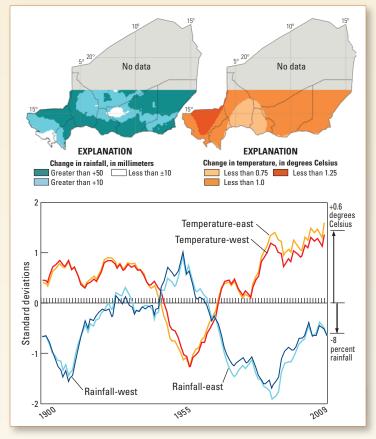


Figure 2. Observed and projected change in June–September rainfall and temperature for 1960–2039 (top), together with smoothed rainfall and air temperature time series for June–September for eastern and western Niger. Mean rainfall and temperature are based on the 1920–69 time period.

warming of the northern Atlantic Ocean (Hoerling and others, 2006); as the northern tropical Atlantic has increased in temperature over this period, this has drawn the summer rains further north, increasing rainfall in the Sahel. These changes can be visualized in three ways: as an expansion of the region receiving adequate rainfall for viable agricultural livelihoods, as maps of anticipated changes in rainfall, and as time series plots.

Niger receives most of its rain between June and September, and rainfall totals of more than 500 millimeters (mm) during this season typically provide enough water for crops and livestock. Between 1960 and 1989, the region receiving (on average) this much rain during June–September is shown in light brown in the left panel of figure 1 and should be understood to lie above the dark brown and orange areas. During the past 20 years, this region has expanded (dark brown polygon), increasing the regions of viable agriculture in Dosso, Maradi, and Zinder (see Objectives and Methods for place names). Cropping areas near 13°N have seen a northward extension of the 500 mm contour.

Rainfall and temperature increases can be visualized by combining the observed 1960–2009 changes with predicted 2010–2039 changes, based on persistence of the observed trends (fig. 2, top panels). Rainfall increases range from 0 to 50 mm across most of the country. Observed changes (between 1960 and 2009) account for 63 percent of the change magnitudes.

A smoothed time series (fig. 2, lower panel, 10-year running means) of rainfall from 1900–2009, extracted for crop growing regions in Niger, indicates that 2000–2009 rainfall has been, on average, about 8 percent lower (-0.6 standard deviations) than the rainfall between 1920 and 1969. For eastern and western Niger, rainfall has steadily recovered since the mid-1970s but remains moderately (less than 0.5 standard deviations) below its long-term mean. These time series were based on crop growing regions in western Niger (Tahoua, Tillaberi, and Dosso regions) and eastern Niger (Diffa, Zinder, and Maradi regions). The Objectives and Methods section gives the population totals for these regions

Much Warmer Air Temperatures

Temperatures have increased by more than 0.7° Celsius (°C) across much of Niger, with typical rates of warming greater than 0.15°C per decade. Assuming the observed trends persist, we can create a composite of observed and anticipated air temperature changes (fig. 2, top panel). Again, observed changes alone (those between 1960 and 2009) account for 63 percent of the change magnitudes. A time series of air temperatures (fig. 2, lower panel) shows that the magnitude of recent warming is large and unprecedented within the past 110 years. Given that the standard deviation of annual air temperatures in these regions is low (approximately 0.5°C), these increases represent a large (approximately 1.5 standard deviation, 0.7°C) change from the climatic norm. This transition to an even warmer climate could reduce crop harvests and pasture availability, amplifying the impact of droughts.

Divergent Climate Trends

The results presented here point to two divergent climate tendencies: rainfall has increased since the 1970s, whereas air temperatures have also increased (fig. 2, bottom panel). Historically (before 1970), increasing air temperatures have been associated with less rain and vice versa; therefore, the unprecedented recent warming with increasing rainfall is probably due to a combination of rainfall enhancements caused by changes in Atlantic Ocean sea surface temperatures (Hoerling and others, 2006) and warming related to greenhouse gas and aerosol emissions. These analyses of station-based temperature data indicate large departures from normal, and this warming trend is projected to persist. Continued rainfall increases are much less certain, since they appear to be linked to natural decadal variations in the Atlantic Ocean.

Population Growth and Stagnating Agricultural Development

In 2011, the estimated population of Niger was 16.5 million people (CIA, 2011). Niger has the highest birth rate of any country and the second highest population growth rate in the world (3.6 percent); at this rate the population will double every 20 years. Between 1990 and 2010, Niger's population increased

by 77 percent, with the largest increases in population occurring in Maradi (2 million), Zinder (1.6 million), and Tahoua (1.6 million). Given that Niger is a landlocked country that depends on agricultural, agro-pastoral, and pastoral livelihoods, this rapid population expansion will place increasing stress on limited natural resources. Only a small fraction (approximately 3.3 percent) of the country receives more than 500 mm of precipitation (fig. 1, left panel), and although recent increases in rainfall have seen this area expand by 25 percent, Niger's expanding food needs may soon outstrip its agricultural expansion. In recent years (2005–2009), per capita cereal production has been reasonably high for Sahelian countries (270 kilograms per person per year; FAO, 2011), but crop statistics from the Food and Agriculture Organization of the United Nations (FAO) indicate that a massive expansion of cultivated area brought about this level of cereal production. Cereal yields are extremely low, and show no positive trends. Between the 1980s and 1990s, the amount of farmland expanded faster (+51 percent) than the population (+37 percent), resulting in a net increase in per capita cereal production. Between the 1990s and 2000s, however, the amount of farmland increased by 20 percent, whereas the population increased by 42 percent, resulting in a net decrease in food availability. By 2025, if Niger's rapid expansion of farmland slows while its yield growth remains stagnant, Niger's projected population of 26 million people could face substantial food availability shortfalls.

Some Implications For Food Security and Adaptation

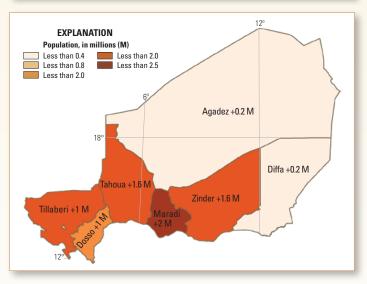


Figure 3. Landscan 2008 population (ORNL, 2010) for Niger along with Gridded Population of the World (CIESIN, 2010) estimates of 1990 to 2010 population change in millions of people.

The results presented here depict a combination of rainfall and air temperature increases. Rainfall increases have supported the large expansion of cultivation in Niger, helping to offset rapid population growth. It remains to be seen, however, if these rainfall increases will persist. In the past, Niger has experienced

large, natural variations in mean rainfall on decadal time scales. If another natural rainfall decline occurs, the impact of this dryness could be augmented by the effects of warmer air temperatures. Given the potential for such a decline, raising yields in wetter areas may be a more viable option than extending agriculture into more marginal areas. However, rapid population growth may make it difficult to slow the process of agricultural extension into marginal areas, and raising yields could lead to improved food availability.

Objectives and Methods

The FEWS NET Informing Climate Change Adaptation series seeks to guide adaptation efforts by providing sub-national detail on the patterns of climate trends already observed in an appropriately documented record. Whether or not these observed trends are related to natural climate variations, global warming, or some combination of the two is less important than knowing now where to focus adaptation efforts.

These FEWS NET reports rely on rigorous analysis of station data, combined with attribution studies using observed climate data. This brief report examines Niger rainfall and temperature trends for the last 110 years (1900–2009) using observations from 209 rainfall gages and 12 air temperature stations for the primary rainy period, June–September. The data were quality controlled, and the mean 1960-89 and mean 1990–2009 station values calculated. The difference between these means was converted into 1960-2009 trend observations and interpolated using a rigorous geo-statistical technique (kriging). Kriging produces standard error estimates, and these can be used to assess the relative spatial accuracy of the identified trends. Dividing the trends by the associated errors allows us to identify the relative certainty of our estimates (Funk and others, 2005; Verdin and others, 2005; Brown and Funk, 2008; Funk and Verdin, 2009; Funk and others, 2011). Readers interested in more information can find these publications at http://earlywarning.usgs.gov/fews/reports.php.

This report was written by Chris Funk and Jim Rowland (both USGS), Alkhalil Adoum (UCSB), Gary Eilerts (USAID), and Libby White (UCSB). It builds upon a multi-year research project (see references below) carried out under a USAID-funded FEWS NET agreement with USGS.

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